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Research Summary
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Assessing the Ecological Risk of Mercury Exposure to Common Loons

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RESEARCH SUMMARY:

Assessing the Ecological Risk of Mercury Exposure to Common Loons

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Beginning in 1999, the Wisconsin Department of Natural Resources, U.S. Geological Survey, and the University of Wisconsin have collaborated on a research project designed to generate a scientifically defensible assessment of the risks to wildlife from exposure to mercury in their environment. The risk assessment focused on the common loon (*Gavia immer*), which is considered to be a sentinel or indicator species that can provide early clues about negative impacts on the natural environment. The two primary goals of the collaborative project were first to determine the toxicity risk posed to the Wisconsin common loon population from excess mercury exposure and second, to develop a model that predicts how this risk changes as atmospheric mercury deposition rates increase or decrease, and/or how mercury concentrations fluctuate in the fish that make up the diet of the loon.

The project was successful in quantifying the rates at which loon systems absorb, metabolize and excrete toxic mercury. This work allowed researchers to create a common loon mercury exposure model that predicts loon chick tissue mercury concentrations as a function of mercury in their diet, their body mass and/or their age (Fournier et al. 2002a, 2002b). It also established a "critical life stage" mercury toxicity threshold (LOAEL - Lowest Observable Adverse Effect Level) by assessing the impacts of mercury exposure on loon chick growth, survival, behavior, and physiology (Kenow et al. 2003a). Researchers were also able to estimate the proportion of the Wisconsin common loon population at risk to mercury toxicity and to predict the population-level impacts (Meyer 2006). Research is ongoing to identify levels of mercury exposure associated with reduced common loon egg hatching rates. Model development continues to predict changes in loon mercury exposure in response to changing atmospheric mercury concentrations.

With funding provided under this Focus on Energy (FOE) Grant, additional work was conducted to finalize and validate the initial predictions of the common loon mercury exposure model, to establish an accurate relation between mercury intake and blood mercury exposure, and to collect tissue partitioning data. Researchers were also able to gather supplemental information concerning the effect of mercury exposure on the immune function and physiology of loon chicks.

The primary purpose of the new study was to develop an empirical relation between mercury content in the dietary fish and the exposure of the loon chicks to mercury, thereby allowing researchers to refine estimates of a mercury toxicity threshold for their risk assessment tool. The results of this work will be used to establish the level of mercury in fish that safeguards survival and health of loon chicks reared on lakes in Wisconsin.

Summary of Results and Accomplishments

To achieve the new project objectives, researchers conducted a chronic dosing study in 2003 using captive-reared loon chicks that were given measured doses of methyl mercury in their diet. Predictions of the mercury exposure model were tested using captive loon chicks growing from hatch to 105 days that were fed rainbow trout injected with controlled quantities of methyl mercury in the form of methyl mercury chloride. This procedure also allowed establishment of the relation between mercury intake and blood mercury exposure.

Observed food intake matched predicted intake according to a bioenergetics model through age 50 days, but then predicted intake exceeded observed intake by an amount that grew progressively larger with age, reaching a significant overestimate of 28% by the end of the trial. There was close agreement between modeled mercury exposure and measured blood mercury, which varied significantly with diet mercury and age. Although chicks may hatch with different blood mercury levels, those differences become unimportant as they age. Beyond about two weeks their blood mercury level was determined mainly by dietary mercury level. This refined model may also be useful for predicting Hg levels in adults, and in eggs that they lay, but the model's accuracy (in both chicks and adults) now needs to be tested in free-living birds.

Researchers also determined the distribution and accumulation of mercury in tissues of common loon chicks maintained for up to 15 weeks on measured diets. Total mercury tissue concentrations were strongly and positively correlated with the amount of mercury delivered to individual chicks throughout the course of the experiment. Mercury concentrations in feathers were consistently higher than that of internal tissues and represented an important route of mercury elimination. Project calculations indicated that over one quarter of ingested mercury could not be accounted for, and thus either was never absorbed or was absorbed and subsequently eliminated in feces. With the additional excretion into feathers, 54% of ingested mercury was excreted.

To assess the relation between mercury exposure and suppressed immune function in loon chicks, researchers conducted a dose-response laboratory study, using skin and blood tests to measure T-lymphocyte and antibody-mediated immunity. Analysis indicated suppression of antibody production at one of the mercury dose levels. Researchers noted that bursal lymphoid depletion occurred with increasing mecury dose and may provide a mechanistic explanation for the observed reduction in antibody production. These findings suggest that common loon chick immune systems, particularly antibody production, may be compromised at an ecologically relevant dietary exposure level.